Crop Phenology for Irrigated Chiles (*Capsicum annuum* L.) in Arizona and New Mexico.

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Abstract

To determine growth and development patterns of irrigated green chile plants as a function of heat units accumulated after planting (HUAP), as well as to develop a general irrigated chile plant development model as a function of HUAP. Field experiments were conducted in 2004 and 20055 at Sunsites in Cochise County, AZ (about 4,000 ft. elevation) and at the Massey Farm in the Animas Valley, NM (about 4,392 ft. elevation). Basic plant growth and development measurements were collected routinely and important phenological stages that corresponded to first bloom, early bloom, peak bloom, physiological maturity, and red harvest were identified and recorded. Results indicate that among all sites, all varieties have performed similarly in relation to HU accumulation patterns and preliminary plant phenology models are under development in this program. The primary difference between sites was that at Sunsites varieties tend to reach a 50/50 (green: red chile) ratio at 2900 HUAP and for Animas valley; this same ratio was reached at 3200 HUAP. Also, a general irrigated green chile plant development model as a function of HUAP for all sites and varieties was obtained. The purpose of this phenological baseline or model is to assist growers in predicting and identifying critical stages of growth for crop management purposes. First bloom occurred at 1369 ± 72 HUAP, early bloom at 1667 ± 79 HUAP, peak bloom at 1998 ± 84 HUAP; physiological maturity at 2285 ± 159 HUAP, and red chile harvest was identified to occur at 3295 ± 216 HUAP.

Key Words: Chile, *Capsicum annuum* L., crop phenology, growth and development, heat units.

Introduction

Chiles (*Capsicum annuum* L.) remain a stable and important crop for several crop production areas in the desert Southwest chile belt (New Mexico, Arizona, Texas, and northern Chihuahua, Mexico). Chiles (green and red) in the Sulfur Springs Valley of Cochise County are primarily produced under center pivot irrigation. Chile jalapeños are produced in Pinal County in central Arizona.

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Recent trends indicate that demands for crops such as chile peppers in the U.S.A. are increasing. As a result, an increase in cultivated chile acreage is needed to meet the market demands for this crop (Johnson and Decoteau, 1996; Johnson and Johnson, 1992). The latest data from the USDA Agricultural Statistics Service showed New Mexico (NM) to be the leading State in chile production in the U.S.A. where about 18,000 acres were committed to production in 2002. Planted acreage in Arizona (AZ) is estimated at 6,000 – 10,000 acres in the recent years. The acreage level has increased in AZ from about 4,000 acres that were reported for 1998. The increase in demand, coupled with more land being committed to chile production has created the need to enhance the basic understanding of chile crop agronomy and general production practices to improve efficiencies.

Accurate prediction of harvest date and developmental stages of a crop has widespread application for improving management of that crop (e.g. fertilization, irrigation, scheduling multiple harvests, pest management activities, labor and machinery, etc.). We often can monitor and predict development based on measuring the thermal conditions in the plant's environment. Various forms of temperature measurements and units commonly referred to as heat units (HU) or growing degree units, have been utilized in numerous studies to predict phenological events for both agronomic and horticultural crops (Baker and Reddy, 2001).

Wurr et al. (2002) stated that to describe crop growth and development there is first the need to determine rate functions for various processes; these include the identification of distinct stages and phases of growth and development, as well as the prediction of duration of developmental phases for given temperature regimes.

At present, there is very limited information available concerning basic crop growth and development for irrigated chiles in the desert southwest. Some relevant information does exist in the literature for chiles but it is very limited in scope and the work has dealt primarily with varieties and cultural practices that have changed considerably in recent years (Beese et al. 1982; and Horton et al. 1982). The literature regarding the basic agronomic aspects of chile production in Arizona is virtually non-existent. Therefore, there is a distinct need to develop an understanding of basic crop phenology in the desert Southwest. Hence, the objectives of this study were: 1) to determine growth and development patterns of irrigated chile plants as a function of heat units accumulated after planting (HUAP), and 2) to develop a general irrigated green and red chile plant development model as a function of HUAP that could be extended as a crop management tool.

Materials and Methods

Field experiments were conducted in 2004 and 2005 at Curry Farms (Mr. Ed Curry, grower-cooperator) on a Borderline fine sandy loam (coarse-loamy, mixed, superactive thermic Typic Calcigypsids) near Sunsites in Cochise County, AZ (about 4,000 ft. elevation) and at the Massey Farm in the Animas Valley, NM (about 4,392 ft. elevation), to conduct phenological monitoring studies of chiles. The project involved the evaluation of a total of 10 Chile varieties being evaluated in the Sulfur Springs Valley of Arizona (near Sunsites, AZ) and the Animas Valley of New Mexico (near Animas, NM). The study areas were planted on 40 in. wide beds at Curry Farms in AZ and 30 in. beds at Massey Farms in NM. All inputs such as fertilizer, water, and pest control were managed on an as-needed basis by the grower-cooperators. Basic agronomic information for all sites is presented in Table 1.

Climatic conditions were monitored and recorded on a daily basis throughout the growing season using an Arizona Meteorological Network (AZMET) station sited near Sunsites, and a New Mexico Climate Station Data (NMCC) for the Animas Valley location. The weather stations near the experimental sites are automated and are used to determine the hourly (AZMET) and daily (NMCC) maximum and minimum temperature values. Consequently, the HU accumulations (86/55 ^{o}F thresholds) are calculated by a method presented in Baskerville and Emin (1969) and modified by Brown (1989). The daily HU accumulations are summed up from the time of planting and reported as HUAP.

In-season data collection for each field was taken from 2m row segments at five randomly selected locations in each field for the entire season and they included the following basic Plant growth and development measurements: number of mainstem nodes from cotyledons to crown formation, height of mainstem from cotyledons to the crown (cm), number of branches and height of each branch formed at the crown, total number of forks and pods formed on each branch, number of white flowers per branch, the number of nodes above the top white flower (NAWF), and above the newest pod position (NAPOD) for each branch. Also, on the red-type chile fields; percent green to red ratios were counted on 14 day intervals. This information provides crop maturity status and a means of comparing earliness or delayed maturities among varieties or cases under study. Plant measurements were made in regular 14-day intervals and the following growth stages were identified in each case: pre-bloom, early bloom, peak bloom (also corresponded to early pod development), and physiological maturity. Statistical analyses were performed on all in-season data collected with statistical procedures consistent with those outlined by Steele and Torrie (1980) and SAS (SAS Institute, 199a and 1999b).

Results and Discussion

Plant growth and development measurements. The 2005 in-season data for all varieties and all sites was collected and tabulated (Figures 1 - 5). In general, the in-season plant measurements provide an indication of the progression of vegetative/reproductive development of the plant along the fruiting cycle. Results indicate that for all site-years all varieties performed similarly in relation to HU accumulation patterns. As a result, preliminary plant phenology models under development in this program can be presented to the program community and given further testing and evaluation in commercial production setting. Further testing of this preliminary model is also continued objective of this research program.

Percent green to red ratio. As presented in Figures 6 and 7, all varieties demonstrated similar rates of transition from green to red chiles. The primary difference between sites was that at Sunsites varieties tend to reach a 50/50 ratio (red:green pods) at 2900 HUAP and for Animas valley; this same ratio was reached at 3200 HUAP.

A general irrigated green chile plant development model as a function of HUAP for all sites and varieties is shown in Table 3. First bloom occurred at 1369 ± 72 HUAP, early bloom at 1667 ± 79 HUAP, peak bloom at 1998 ± 84 HUAP; physiological maturity at 2285 ± 159 HUAP, and red chile harvest was identified to occur at 3295 ± 216 HUAP.

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Table 1. Basic agronomic information for chile experiments; Sunsites, AZ and Animas Valley, NM, 2004-2005.

Site	Variety	Wet Date	Irrigation Type	Soil Type
Sunsites	AZ 20	3/23/04	Sprinkler	Fine sandy loam[1] [coarse-loamy, mixed, superactive thermic Typic Calcigypsids]
	AZ 8 AZ 8 AZ 21 AZ 335-270 Esquina Ancho X Chile AZ 20	3/23/04 4/12/05 4/25/05 4/25/05 4/01/05 3/14/05 3/25/05	Drip	
Animas Valley	Grande B58 300 LB 25	4/04/05 4/07/05 4/07/05 4/07/05	Sprinkler	

1] USDA. (2003).

Table 2. Sampling dates for chile experiments; Sunsites, AZ and Animas Valley, NM, 2004-2005.

Site	Variety	First Bloom	Early Bloom	Peak Bloom	Physiological maturity
Sunsites	AZ 8	6/23/04	7/13/04	7/29/04	8/31/04
	AZ 20	6/23/04	7/13/04	7/29/04	8/31/04
	AZ 8	6/08/05	6/23/05	7/20/05	8/17/05
	AZ 21	6/23/05	7/06/05	7/20/05	8/17/05
	AZ 335-270	6/23/05	7/06/05	7/20/05	8/17/05
	Esquina	6/08/05	6/23/05	7/20/05	8/17/05
	Ancho X Chile	6/08/05	6/23/05	7/20/05	8/17/05
	AZ 20	6/08/05	6/23/05	7/20/05	8/25/05
Animas Valley	Grande	6/30/05	7/15/05	7/29/05	8/27/05
	B58	6/30/05	7/15/05	7/29/05	8/27/05
	300	6/30/05	7/15/05	7/29/05	8/27/05
	LB 25	6/30/05	7/15/05	7/29/05	8/27/05

Sunsites 2004

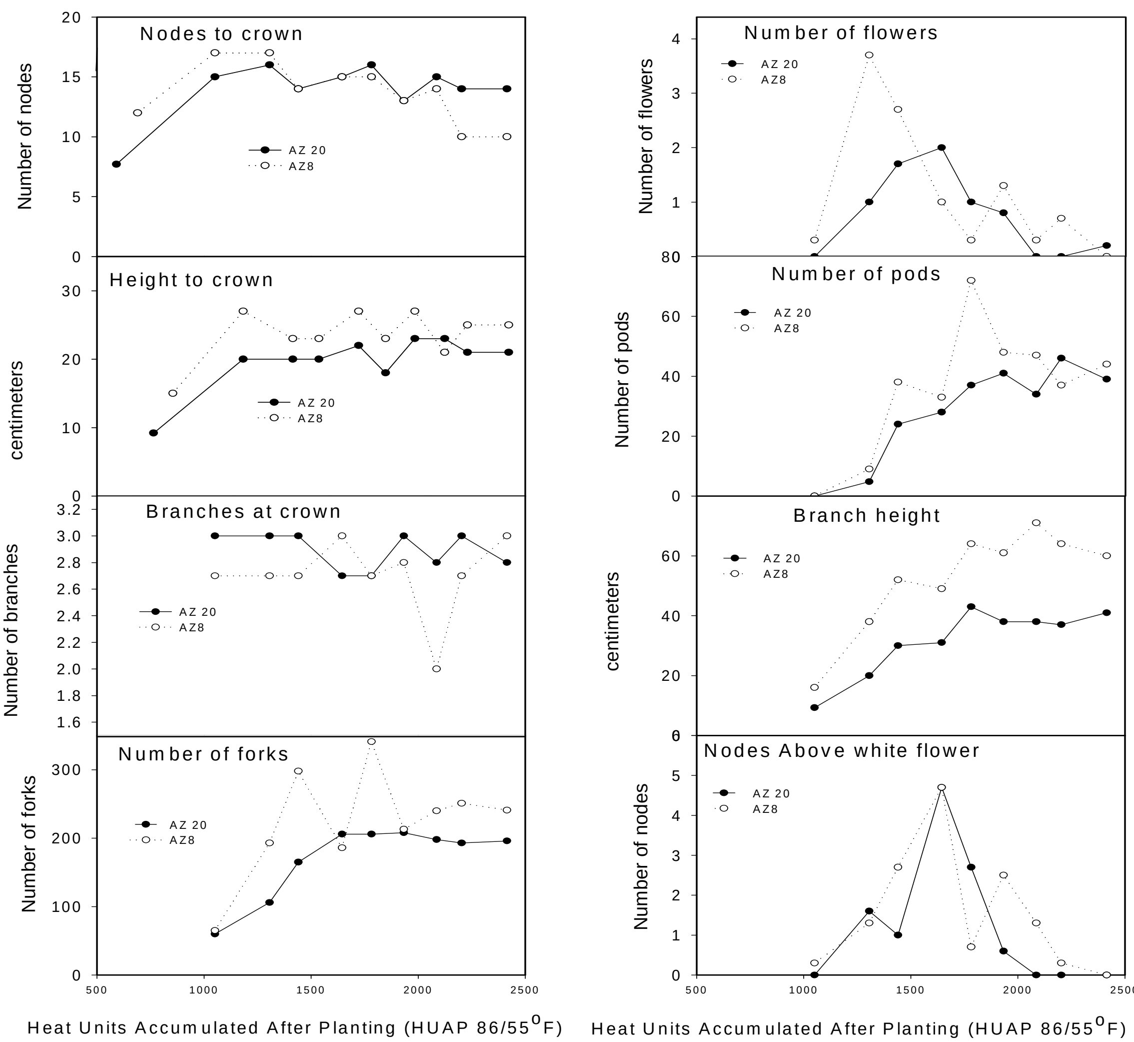


Figure 1. Growth and Development variables as a function of HUAP for all chile varieties.
Curry's Farm. Sunsites, Az. 2004.

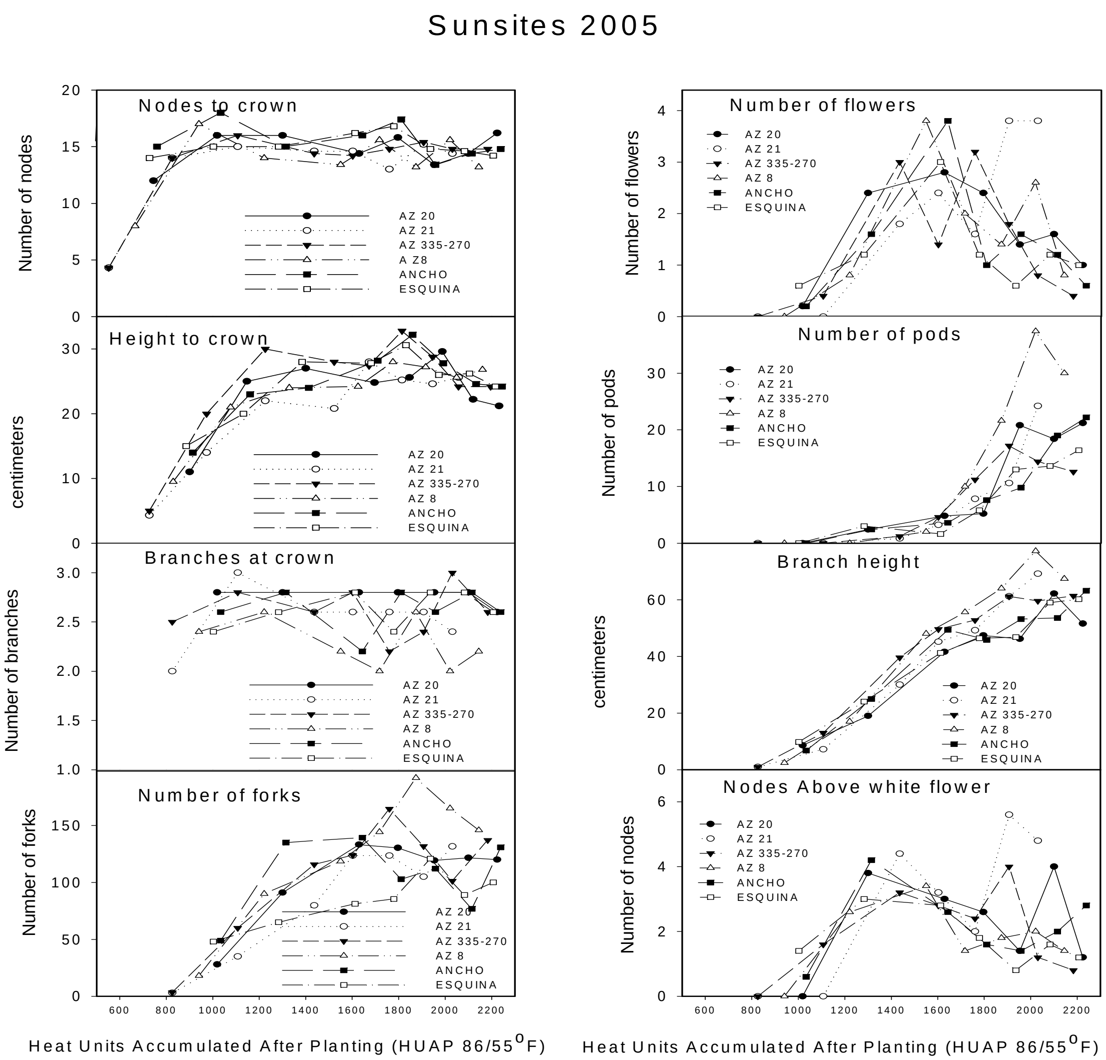
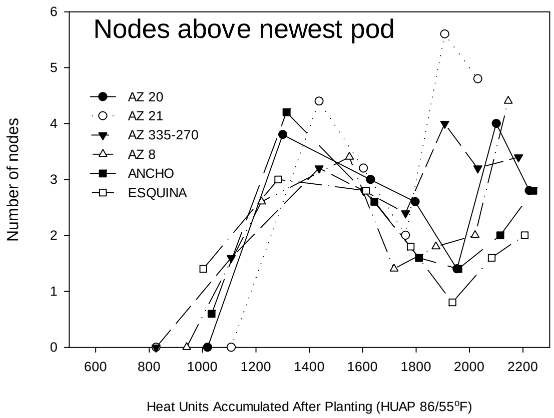


Figure 2. Growth and Development variables as a function of HUAP for all chile varieties. Curry's Farm. Sunsites, Az. 2005.

Sunsites 2005



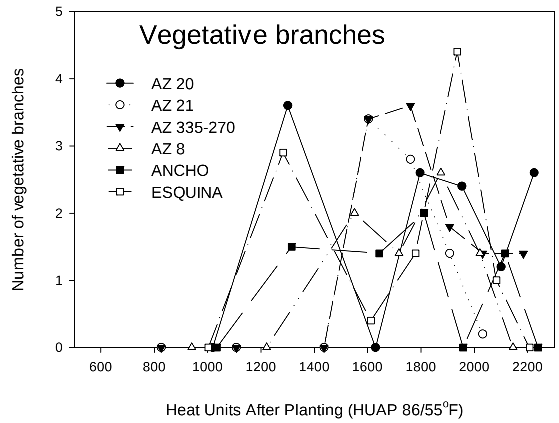


Figure 3. Growth and Development variables as a function of HUAP for all chile varieties. Curry's Farm. Sunsites, Az. 2005.

Animas 2005

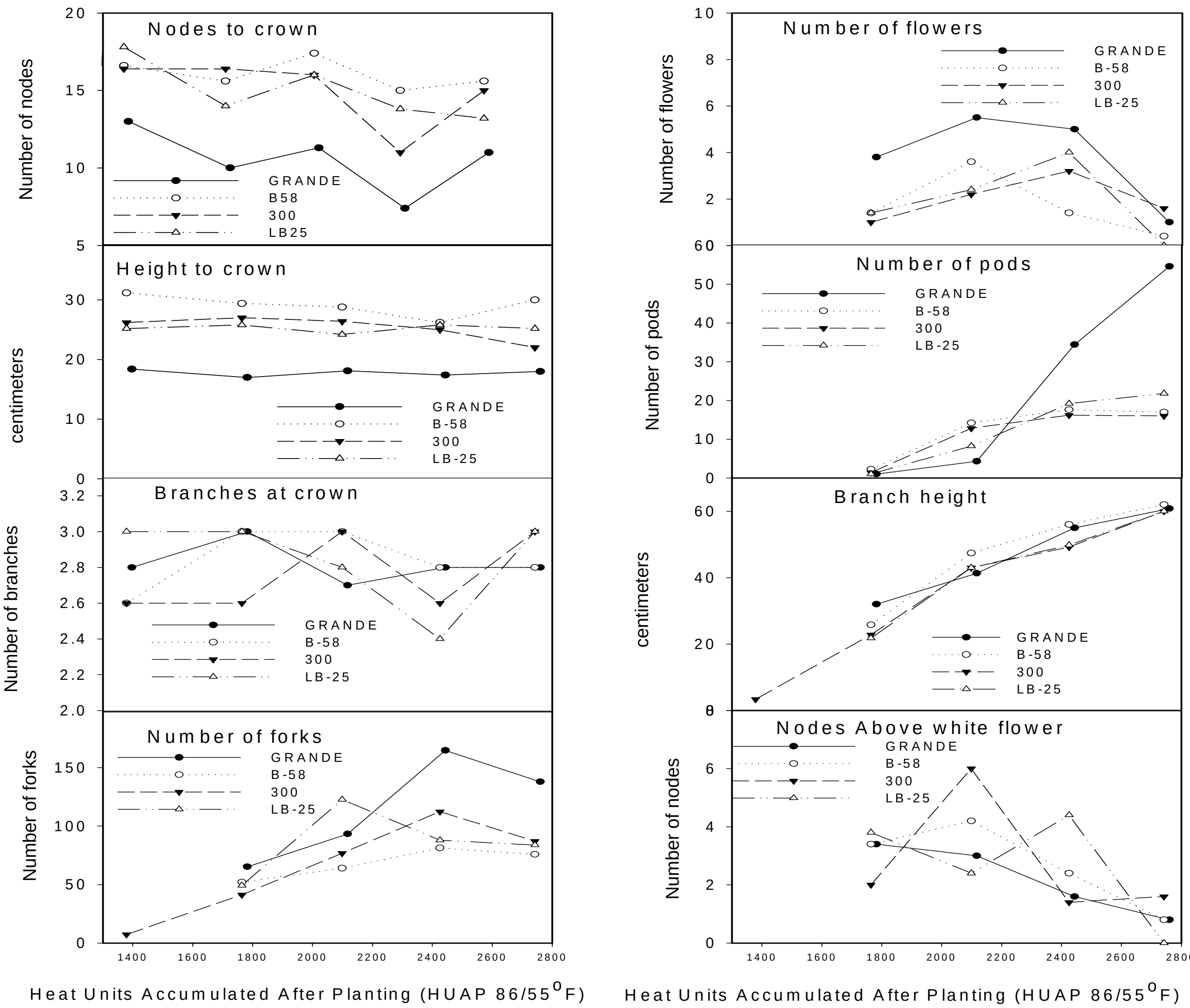


Figure 4. Growth and Development variables as a function of HUAP for all chile varieties. Massey's Farm. Animas, Nm. 2005.

Animas 2005

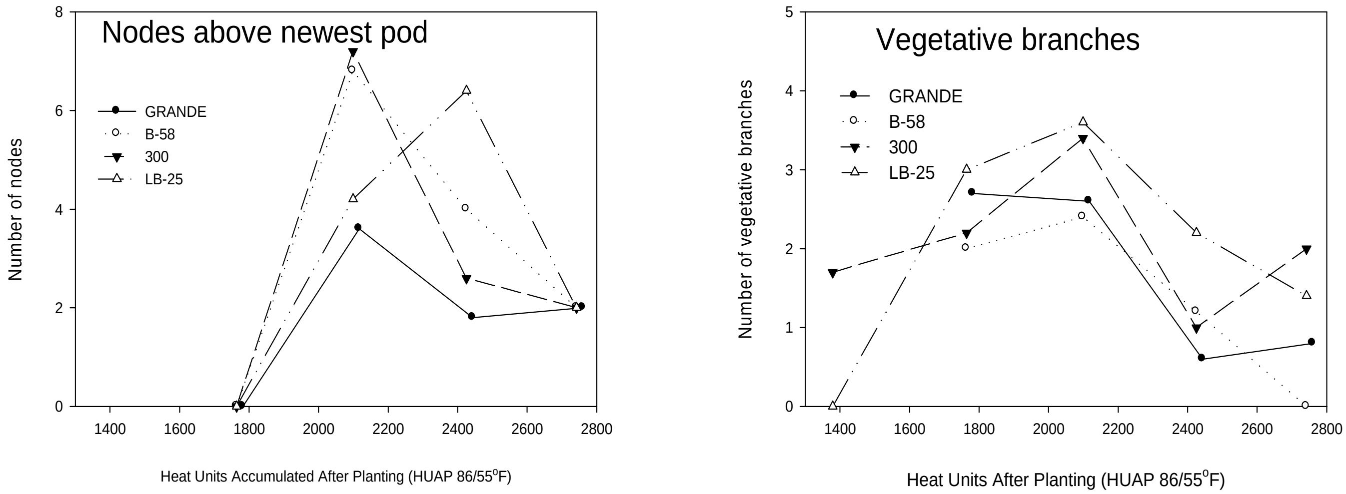


Figure 4. Growth and Development variables as a function of HUAP for all chile varieties. Massey's Farm. Animas, Nm. 2005.

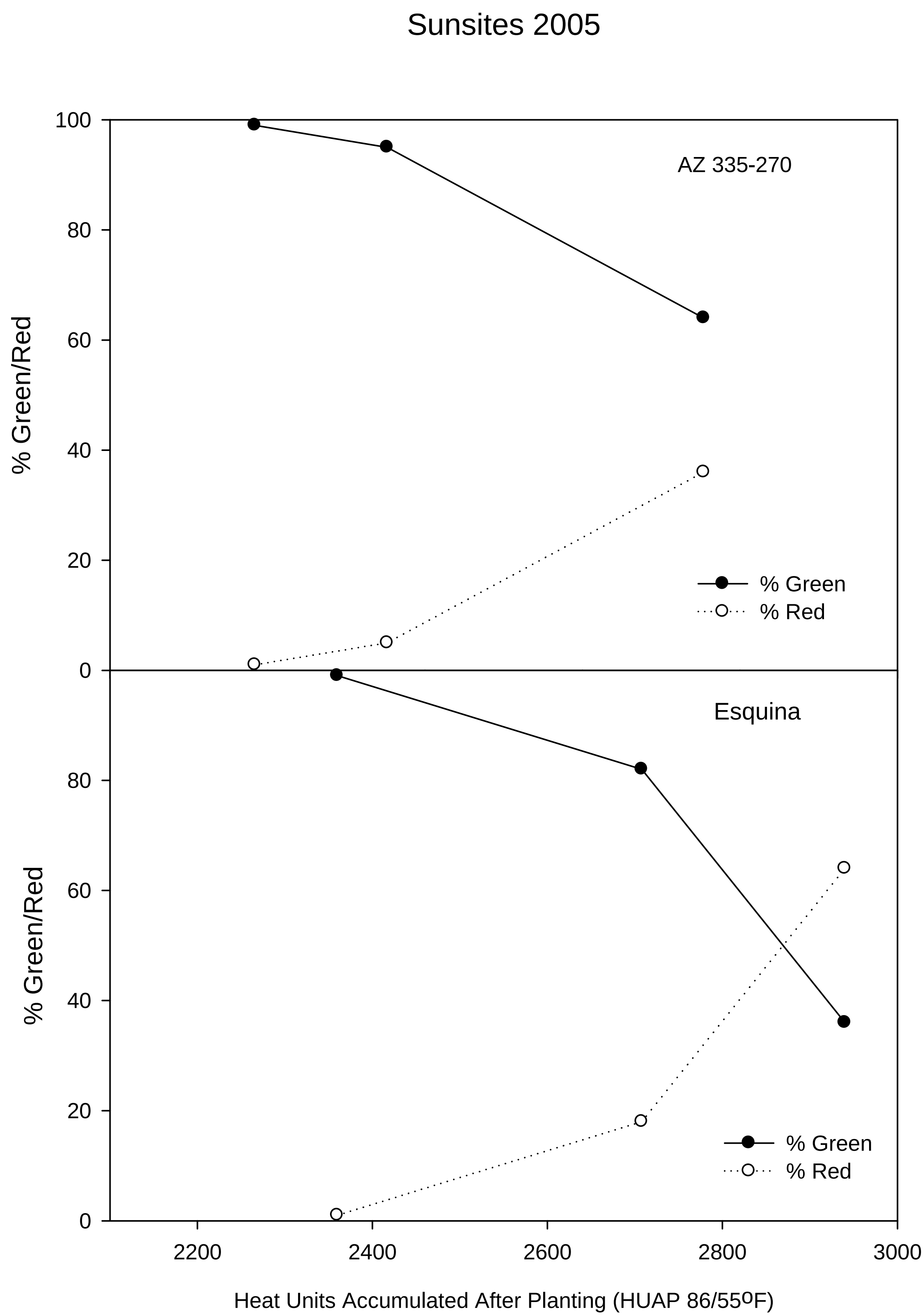


Figure 5. Percent green to red ratio of AZ 335-270 and Esquina as a function of HUAP. Curry's Farm. Sunsites, Az. 2005.

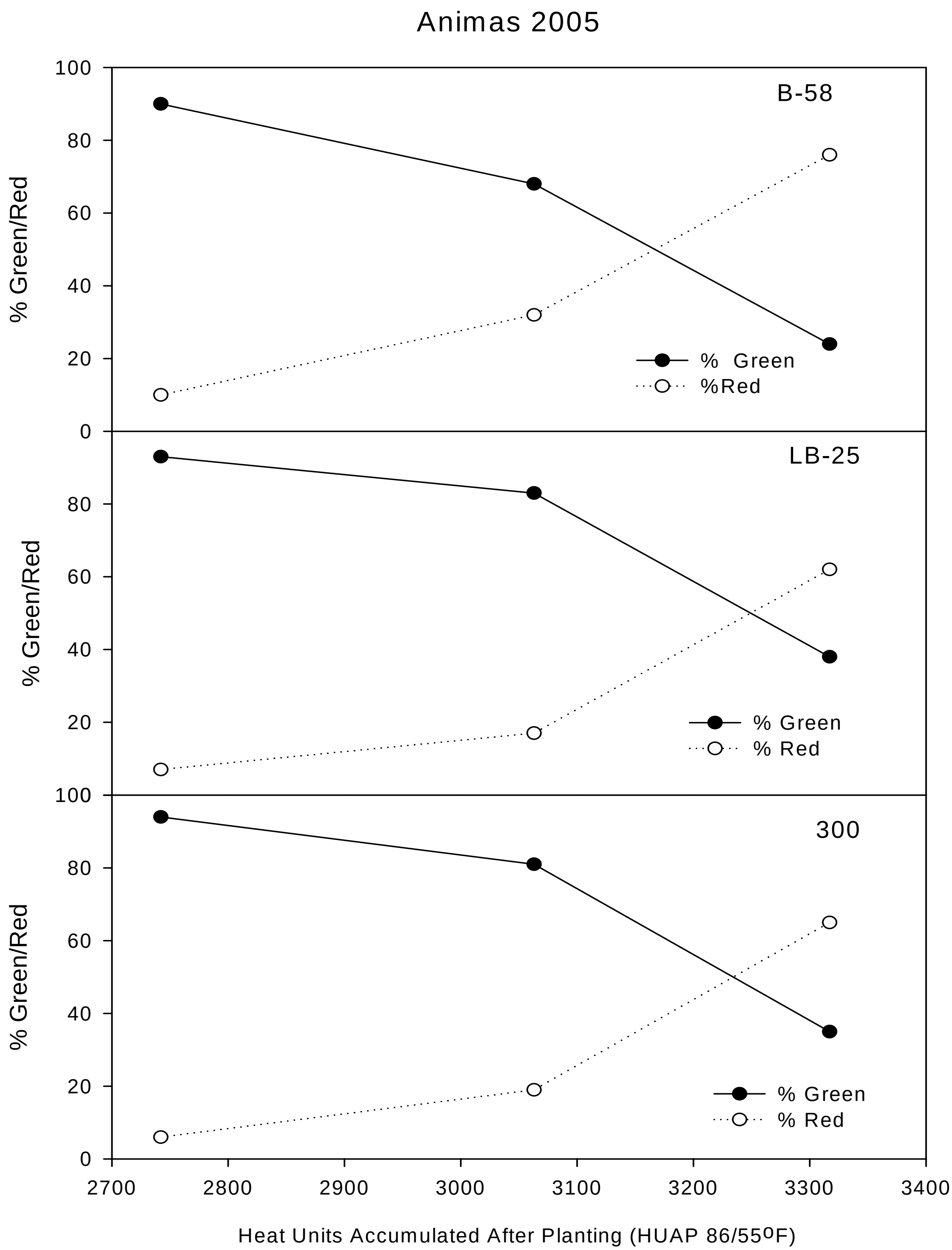


Figure 7. Percent green to red ratio of B-58, LB-25 and 300 as a function of HUAP.
Massey's Farm. Animas, NM. 2005.

Table 3. Chiles phenological stages as a function of Heat units accumulated after planting (HUAP), Arizona. 2004-2005.

		HUAP (86/55 °F threshold).	
Site	**Phenological Stage**	**Mean**	**Standard Deviation**
Sunsites, Arizona.	First Bloom	1359	89
	Early Bloom	1616	32
	Peak Bloom	1945	37
	Physiological Maturity	2213	148
	Red Harvest	3112	124
Animas,Valley, New Mexico.	First Bloom	1388	10
	Early Bloom	1769	9
	Peak Bloom	2104	9
	Physiological Maturity	2430	9
	Red Harvest	3416	172
Combined	First Bloom	1369	72
	Early Bloom	1667	79
	Peak Bloom	1998	84
	Physiological Maturity	2285	159
	Red Harvest	3295	216